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2 A coin and a feather are dropped from the same height, through air.

Which row of the table is correct as the coin and feather fall to the ground?

	Initial acceleration	Time taken to reach the ground
☒ **A**	Greater for coin	Less for coin
☒ **B**	Greater for coin	Same for coin and feather
☒ **C**	Same for coin and feather	Less for coin
☒ **D**	Same for coin and feather	Same for coin and feather

(Total for Question 2 = 1 mark)

Questions 5 and 6 refer to the information below.

Two groups of students were asked to perform an experiment to determine the acceleration of free-fall. Each group repeated their experiment three times to check their results. In each experiment a steel ball fell through a height of just under 1 m and the time for the ball to fall was measured.

- **Group 1** used a stopwatch to measure the time.
- **Group 2** used light gates connected to a data logger to measure the time.

5 The students measured the height the ball fell using a metre rule.

The height should be recorded as

☒ **A** 85 cm

☒ **B** 0.85 m

☒ **C** 0.850 m

☒ **D** 8.5×10^{-1} m

(Total for Question 5 = 1 mark)

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DO

8 A ball is thrown vertically upwards with a velocity of $+3.0\,\text{m s}^{-1}$.

Which of the following is the acceleration of the ball at its maximum height?

A $0\,\text{m s}^{-2}$

B $-3.0\,\text{m s}^{-2}$

C $+9.8\,\text{m s}^{-2}$

D $-9.8\,\text{m s}^{-2}$

(Total for Question 8 = 1 mark)

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7 A ball bearing falls vertically from rest through a distance of 50 cm in a time of 0.32 s.

Which expression gives the acceleration of the ball bearing in $m\,s^{-2}$?

☒ **A** $1 \div 0.32^2$

☒ **B** $0.5 \div 0.32$

☒ **C** $100 \div 0.32^2$

☒ **D** $50 \div 0.32$

(Total for Question 7 = 1 mark)

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4 A projectile is launched at an angle θ to the horizontal and takes a time t to reach its maximum height.

Which of the following equations could be used to determine the initial velocity u of the projectile?

☒ **A** $u = \dfrac{gt}{\cos\theta}$

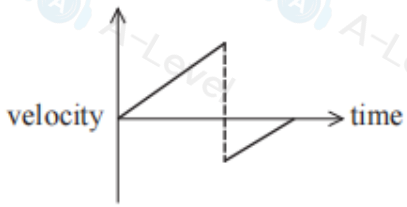
☒ **B** $u = \dfrac{-gt}{\cos\theta}$

☒ **C** $u = \dfrac{gt}{\sin\theta}$

☒ **D** $u = \dfrac{-gt}{\sin\theta}$

(Total for Question 4 = 1 mark)

The velocity-time graph for the motion of a ball is shown.



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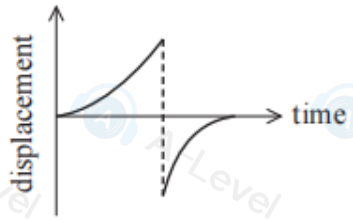
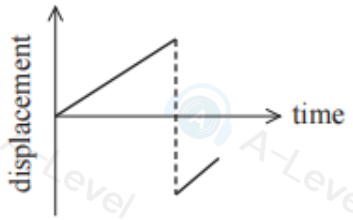
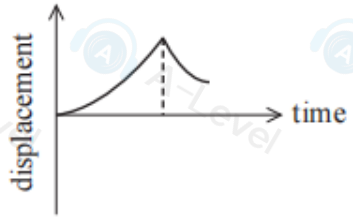
10 Which of the following graphs of displacement against time could represent the motion of the ball?



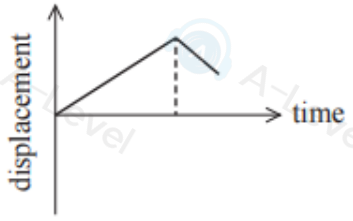
A



B



C



D

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 10 = 1 mark)

4 The manufacturer of a car claims that the car can accelerate from rest to $30\,m\,s^{-1}$ in 7.5 s.

What is the average acceleration of the car over this time period?

☐ **A** $0.53\,m\,s^{-2}$

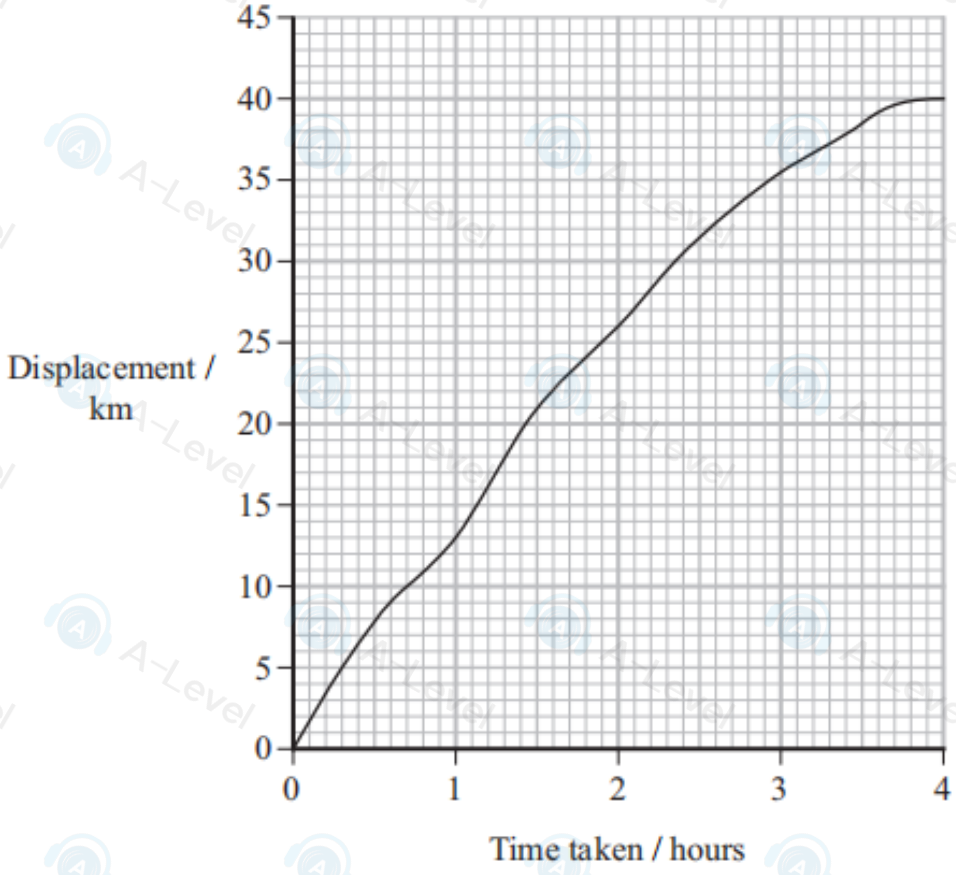
☐ **B** $2.0\,m\,s^{-2}$

☐ **C** $4.0\,m\,s^{-2}$

☐ **D** $8.0\,m\,s^{-2}$

(Total for Question 4 = 1 mark)

3 The displacement-time graph for a person running a race is shown.



Which of the following gives the average velocity of the person?

- ☒ **A** area between the curve and the *x*-axis from 0 hours to 4 hours
- ☒ **B** gradient of a tangent to the curve at 4 hours
- ☒ **C** gradient of a tangent to the curve at 2 hours
- ☒ **D** displacement at 4 hours divided by a time of 4 hours

(Total for Question 3 = 1 mark)

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4 A car travels north with a velocity of $+50\,m\,s^{-1}$. While still travelling north, the car slows to a velocity of $+20\,m\,s^{-1}$.

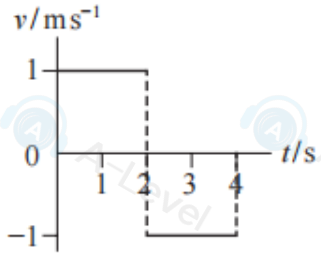
Which of the following is the change of velocity of the car?

- ☒ **A** $+30\,m\,s^{-1}$
- ☒ **B** $-30\,m\,s^{-1}$
- ☒ **C** $+70\,m\,s^{-1}$
- ☒ **D** $-70\,m\,s^{-1}$

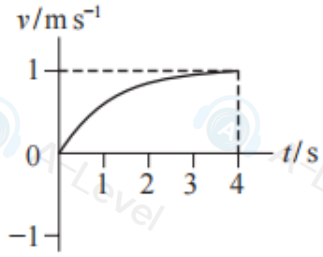
(Total for Question 4 = 1 mark)

AREA

5 Two objects P and Q are at the same position at time $t = 0$ s. The graphs show how the velocity v varies with time t for each object.



object P



object Q

Which of the following statements describes the positions of P and Q at $t = 4$ s?

- ☒ **A** P and Q are both at the initial position.
- ☒ **B** P and Q are the same distance from the initial position.
- ☒ **C** P is further from the initial position than Q.
- ☒ **D** Q is further from the initial position than P.

(Total for Question 5 = 1 mark)

14 A firework is launched into the air and explodes once it reaches a maximum height.

(a) The firework is designed to explode at a maximum height of 350 m.

(i) Show that the vertical component of the velocity at launch is about 80 m s^{-1}.

(2)

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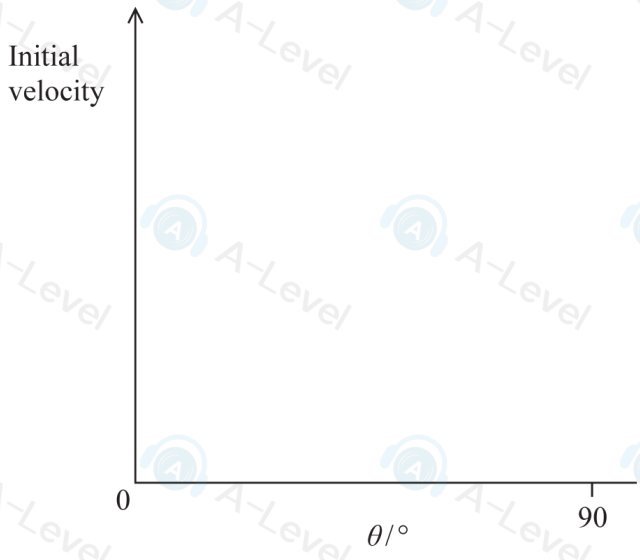
(ii) The vertical component of the velocity at launch depends on both the initial velocity of the firework and θ, the angle between the initial velocity and the horizontal.

Sketch a graph showing how the initial velocity required for the firework to reach the maximum height of 350 m varies with θ for the firework.

(4)



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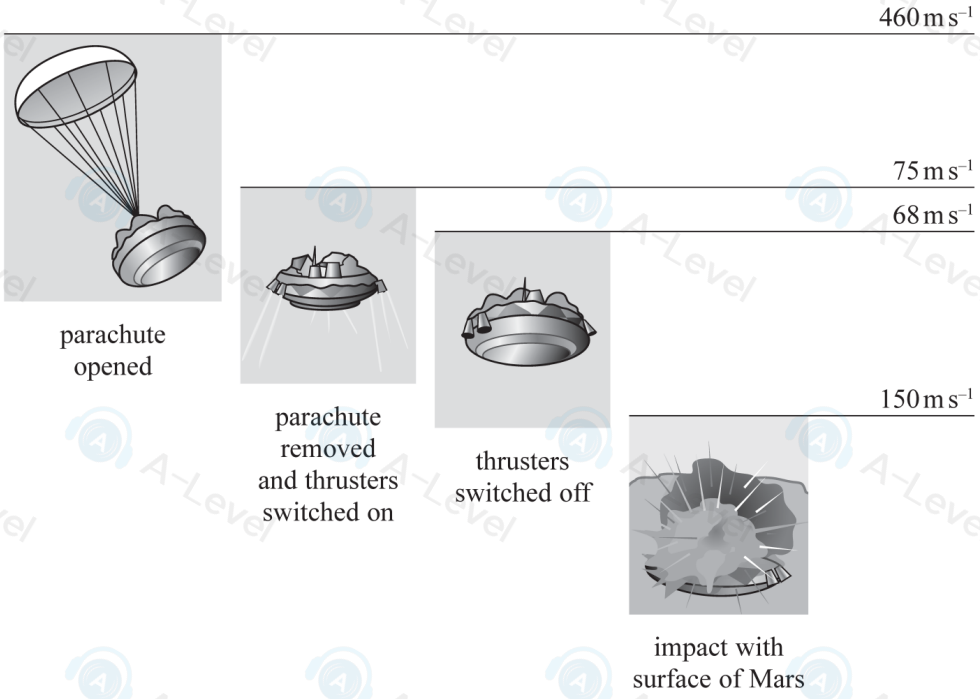
16 In 2016, the European Space Agency sent the Schiaparelli probe to Mars.

As the probe approached the surface of Mars, with a vertical velocity component of $460\,m\,s^{-1}$, a parachute was opened to reduce the speed of the probe. Once the vertical velocity of the probe had reduced to $75\,m\,s^{-1}$, the parachute was removed and the thrusters were switched on.

Due to an error the thrusters were switched off too soon, leaving the probe to 'free fall' to the surface of Mars.

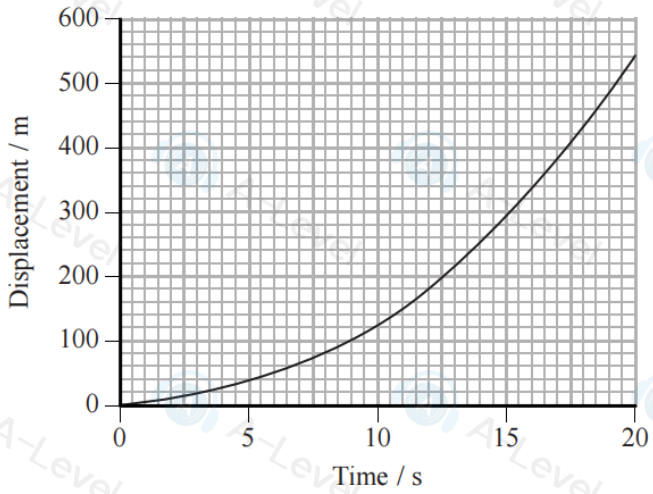


(a) The parachute was used over a decrease in height of 9.7 km.

(i) Show that the average vertical deceleration of the probe due to the parachute was about $11\,m\,s^{-2}$.

(2)

15 The graph shows how the displacement of a racing car along a straight track varies with time.



(a) A student used the graph to calculate the velocity of the car at 15 s.

The student wrote:

Velocity = displacement / time
= 300/15
= 20 m s^{-1}

State why this value is incorrect and calculate the correct velocity at 15 s.

(3)

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Velocity of the car at 15 s = ...

(b) The gradient of the graph continued to increase as the car travelled along the track. After 20 s the rate of increase of the gradient began to decrease.

Explain why the rate of increase of the gradient decreased.

(2)

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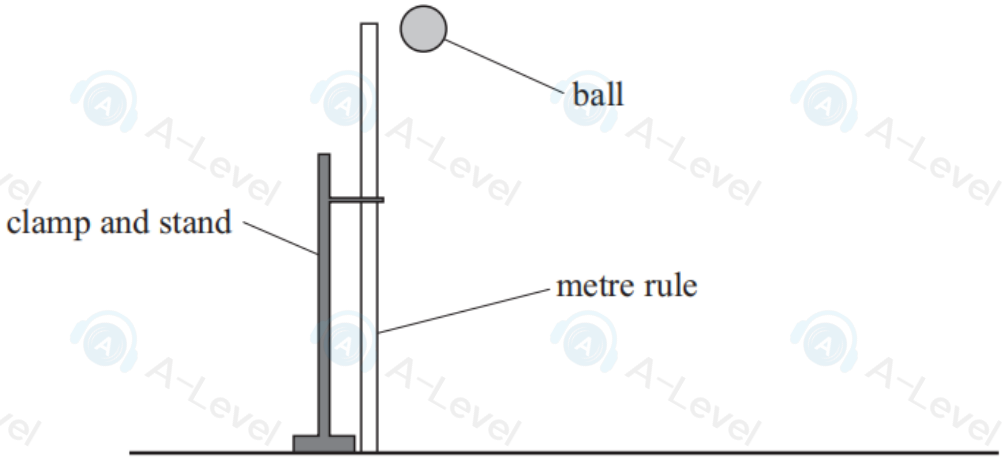
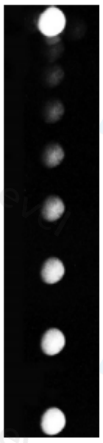
(Total for Question 15 = 5 marks)

14 A student clamped a metre rule so that it was vertical. She dropped a ball from rest near the top of the metre rule, as shown.



A strobe emits flashes of light. The time interval between flashes is constant.

The student photographed the falling ball using strobe lighting. The ball can be seen at different heights in the photograph, as shown.



(Source: © sciencephotos/Alamy Stock Photo)

For each flash of light, the student determined the distance fallen by the ball.

(a) She took one photograph using a strobe app on a mobile phone.
She took a second photograph using a laboratory strobe.

The time interval between flashes was the same for the strobe app and for the laboratory strobe. Each flash of light from the laboratory strobe has a smaller duration than each flash from the mobile phone.

Explain how the smaller duration of each flash from the laboratory strobe affected the uncertainty in the measurement of the distance fallen.

(2)

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(b) The student recorded the distances s fallen by the ball and corresponding values of the time t.

(i) Explain why a graph of s against t^2 gives a straight line.

(2)

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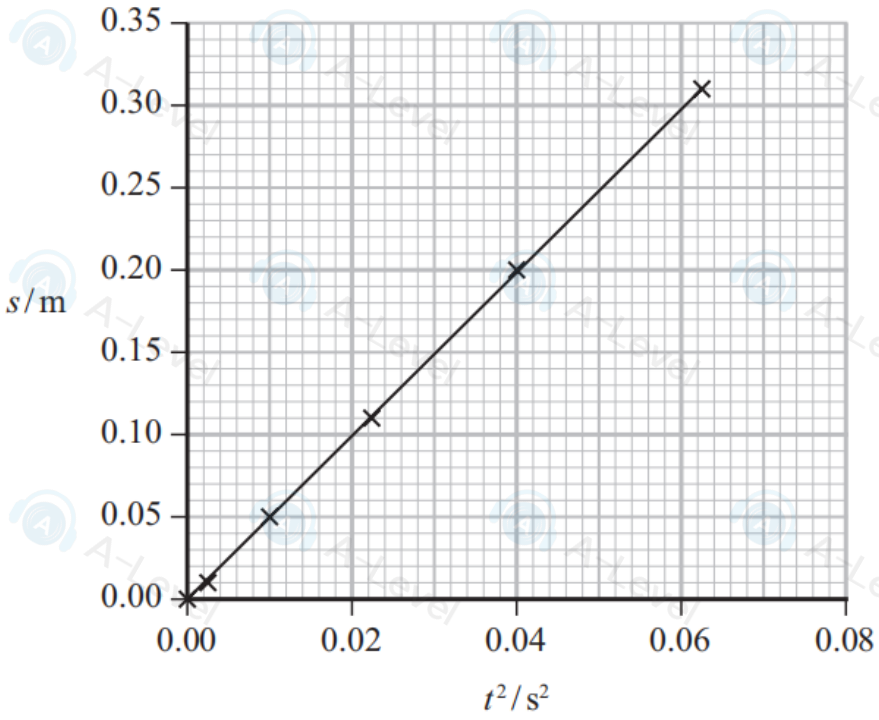
.....

(ii) The student plotted a graph of s against t^2, as shown.



Determine the acceleration of free fall, g, using the student's graph.

(2)

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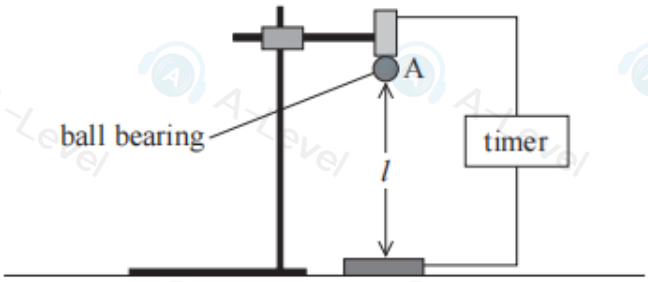
g = ...

(Total for Question 14 = 6 marks)

11 A student carried out an experiment to measure the acceleration of free-fall g.

A ball bearing was released from position A. The time t for the ball bearing to fall a distance l was measured. This was repeated for decreasing values of l.



Explain how the measurements obtained can be used to determine a value for g in m s^{-2}. Your answer should include a sketch on the axes below of the graph that the student would expect to obtain.

(5)

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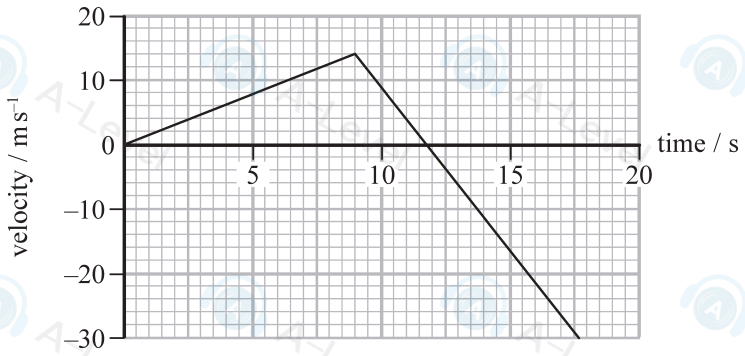
SECTION B

Answer ALL questions in the spaces provided.

11 The graph shows how the velocity of an object varies with time.



Describe how the acceleration of the object varies with time.
Your answer should include calculations.

(3)

(Total for Question 11 = 3 marks)